Rio Grande do Sul, on the contrary, there are few slaves, and most of these are on the cattle-estates of the south. The free laborer is honored because experience has shown that his industry leads to wealth; there are few large estates, and land can always be purchased on favorable terms. Formerly there was much jealously of the foreign element, but this has nearly disappeared. Finally, the immigrant is contented and happy, because he can mingle with others of his own race, and because he knows that he is creating a bright future for himself and his children.

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THE POLAR ORGANIZATION OF ANIMALS.

BY CHARLES MORRIS.

IN previous papers by the writer under the title of "Organic Physics,"[1] certain fundamental characteristics of protoplasm were considered, and their relation to the functional conditions of the developed animal body traced. There are still other basic conditions in protoplasm which are directly related to the functions of the developed animal. There is no just reason to doubt, indeed, that each separate mass of living protoplasm generalizes in itself all that we find specialized in the highest animal, and that there is no condition unfolded in the man which does not exist potentially in the rhizopod. It is hoped here to show another of those interesting relations.

The self-living mass of protoplasm appears to be a polar organism in a double sense. It seemingly possesses a lateral or chemical polarity, which develops into the sexual polarity of animals. The self-division of the rhizopod is a reproductive function strictly analogous to that existing in the developed animal, and the sexual polarity of the former appears to be represented by a lateral sexual polarity in the latter, the two similar halves of the animal being the two poles in a complete double-sexed organism. This form of polarity has been considered in detail in the papers above referred to. But there is another polarity, which in the rhizopod displays itself in a differentiation of the exterior and the interior functions of the mass. The external region is sensitive, the internal nutritive in function. This statement has more in it than may at first sight appear, for it expresses an organic relation that con-

[1] AMERICAN NATURALIST, June, July and August, 1882, February and March, 1883.

trols the whole development of the animal kingdom, and is as strongly displayed in the man as in the protozoan. Both alike possess a distinct nutritive and sensory polarity, each of these functions having its separate pole.

This polarity is, in fact, particularly displayed in the fully progressed animal, as we shall hope to show. In its generalized condition, in the rhizopod, it consists of a differentiation of function in the two regions of the body. The external layer of the rhizopodal body alone comes into contact with and feels the impressions of outer force. Thus such sensitiveness as is possessed must be confined to this layer. The impressions received, however, seem to extend inwardly, and to result in the production of a motor function. The internal layer, on the contrary, is distinctly nutritive in function. The food is, in various methods, brought into contact with it, digested and assimilated. And as the sensory impressions received by the external layer are transmitted and produce motion throughout the entire body, so the nutriment received by the internal layer is diffused throughout and assimilated by the entire body.

At the very outset of life, therefore, a separation of its two active functions takes place as a necessary result of the opposed relations of its substance. The external layers of protoplasm become opposite in function to the internal. Contact, irritation, motor instigation, have their seat in the surface, and proceed inward. Nutrition has its seat in the interior, and proceeds outward. The development of the one tends to the production of special channels of sensory inflow, and special regions of motor contraction. The development of the other tends to the production of special digestive regions and special channels for the conveyance of nutriment. Thus the sensory and motor functions of the body originate in the surface and spread inward. Its vascular functions originate in the interior and spread outward. These separate functions are distinct only as regards their points of origin and their characteristics, for throughout the whole intermediate region they inosculate and interweave with each other.

The separation of functional regions, thus indicated in the Protozoa, is markedly displayed throughout the whole line of development of the Metazoa. In all the Metazoa an early step of embryonal differentiation is the formation of two distinct layers of cells, one bounding an internal cavity, the other forming a surface

layer. The former is the seat of the nutritive, the latter of the sensory function. Thus very early in life the animal possesses a digestive and a sensitive layer of cells. It is an animate stomach with a sensitive outer skin. There is no chemical differentiation of tissue. The duty performed by each layer of cells is a consequence of its position. The hydra, for instance, may be turned inside out, and the functions of the two layers become reversed without injury to the animal. In the higher animals, however, these two layers grow unlike in character and incapable of replacing each other. And yet in the highest animal there may be no fundamental distinction. Each layer gains special organs, which would not subserve the purpose of the other, but the character of their protoplasm may remain unchanged.

Between these two layers arises a third, the mesoderm, whose origin is yet somewhat unsettled, though there is no reason to doubt that it springs from one or both of the original layers. An examination of this mesodermal layer, from the point of view here taken, leads to certain interesting conclusions. For, in the highest animals, we find it to consist of several distinct tissues, which we may generalize into three. One of these is the nervous and its related muscular tissue. A second is the vascular and its related lymphatic tissue. The third is the connective or supporting tissue, with its various forms of fiber, cartilage, bone, &c. The mesoderm, then, seems to be a direct outgrowth of both the endodermal and ectodermal layers. The external layer pushes inward its channels of sensory inflow, which permeate every region of the body, each line of inflow terminating in a muscle, or motor organ. The internal layer pushes outward its channels of nutritive outflow, which permeate every region of the body, and as the nerves may be said to deposit their conveyed force in the muscles, so the vessels deposit their conveyed nutriment in the lymphatic assimilative spaces. This is really about all we find in the body, complicated as it may appear. If we consider its basic characteristics, we are brought back to the two original layers, or even to the external and internal regions of the rhizopod. As the body grows in bulk the external layer extends itself inward in a complex mass of nerve conductors, nerve cells and muscles. In like manner the internal layer extends itself outward, in an equally complex mass of blood channels and lymph vessels. So far, therefore, we have but the two primary layers, with their inti-

mately interwoven outgrowths. In the interspaces of these organs other matter is deposited, which serves for their support and forms the connective tissues.

Such is the true character of the mesoderm. The wall of the inner cavity becomes the digestive region of the body. It differentiates accordingly, involutions of it compose the various glands which aid digestion, and blood vessels which have their true origin in its walls, carry the nutriment which it yields to all parts of the interior. So the outer wall becomes the sensory layer of the body, and sends its nerve channels inwards to convey motor energy to muscles, which are, fundamentally, but special arrangements of nerve extremities. The mesoderm consists of these outwardly-pushing nutritive and inwardly-pushing motor channels, with the connective tissues necessary for their support. The remaining general function of the body, that of the elimination of waste and discarded material, is effected through the aid of both layers.

So far we discover in the highest animal only a direct unfoldment of what exists in the lowest. Protoplasm may be homogeneous in structure, and every portion of it at once sensitive to external contact and assimilative of nutritive material. But the different relations of its different regions necessitates an early differentiation of function. It becomes externally sensory, internally nutritive. And in the highest animals this differentiation continues. It is remarkably unfolded, but there is nothing added to it. Its original vagueness, however, becomes a marked specialization. We find in the simplest protozoan a double polarity vaguely declared. The first is a chemical or sexual polarity, in which the two lateral halves of the mass are concerned, and whose eventual result is the division of the mass into two vitalized halves. The second is a sensory-nutritive polarity, of which the external and internal regions of the body mass become the poles. Both these polarities are direct results of the native conditions of protoplasm and its relations to external nature. And in the highest animals we find nothing more than an extension of these differentiations of condition and function, and a more specialized display of these polarities. The sexual polarity seems to still affect the two opposite lateral regions, so that every animal, except as warped by the pressure of life conditions, is symmetrically duplex, the two similar halves being, as we believe, the male and female poles of a

double-sexed organism. In the higher animals a superior differentiation arises, in the division of sexual polarity between distinct individuals, yet its minor phase of the doubly-sexual organization of each individual, is still retained.

The other polarity of protoplasm mentioned is equally declared in the highest animals. As the former remains a lateral, this becomes a longitudinal polarity, as we shall seek to show. Originally it is a polar or functional difference of the external and internal layers. This distinction persists in the highest animals, but each of the two functions gains its distinct pole.

The pole of the sensory function is not difficult to discover. It becomes gradually declared as we ascend beyond the lower animals, and displays itself in all the higher animal forms as the brain. This organ is the center of the motor and sensory nerve fibers which collects, retains and again disseminates the impressions arising from external contact. Such an organ is perhaps not needed by lower organisms. Their defective sensory and motor organs render them but feebly sensitive to impression, and they can easily respond to every contact of sufficient vigor to overcome the sluggishness of their organs of sensation. But the whole course of development is towards a greater and more diversified sensitiveness of the animal form. The highest animals respond to impressions of excessive delicacy. Almost every force influence of the outer world is capable of affecting them, while their complex muscular organization permits of a great variety of responsive motions.

Yet evidently a movement in response to every impression, after such extreme sensitiveness is attained, would be decidedly injurious. The vigor of the organism would be exhausted. Thus with the increase of sensitiveness there became necessary the evolution of some discriminative organ, some center of sensation, in which the motor energies received could be retained, and from which the movements of the muscles could be controlled, only such impulses as were likely to be beneficial to the organism being permitted to pass onward. With the *modus operandi* of this process we are not here concerned. It suffices that a power of retention of and descrimination between nerve impressions became necessary ere any high development could be gained, and that the brain was evolved as the organ of this retention. The brain is, therefore, the true pole of the sensory function. Thither flow all

the motor energies received from the outer world through the nerve channels. There these motor influences are combined and retained, in some method which is yet a mystery, until the highly complex relations of the mental organism are produced. Thus the conscious mind is the final outcome and the highest product of the combination of motor energies, and the brain the governing organ through which the movements of the body are controlled.

But the nutritive function has likewise its organic pole, in which the final and highest product of its exercise is laid up. In "Organic Physics" this question has been considered. The building up and repair of the solid tissues of the body is only one of the results of the nutritive process. A second result we conceive to be the formation of the concreted portions of the liquid tissues—the white corpuscles or leucocytes. And the ultimate result of this process is the aggregation of the leucocytes into more and more complex corpuscles, until, in their final and most complex stage, they are excreted by the reproductive glands as the germs of new organisms. The formation of such a germ is the final outcome of nutrition. In this germ the organic product has reached its highest stage of synthesis. Chemical assimilation and molecular complexity have attained their ultimate, and the germinal cells exist as epitomes of the whole body. From this point of view the reproductive organs form the nutritive pole of the body.

Thus as the conscious mind is the highest product of the combination of motor energies, so the ovum or spermatozoön is the highest product of the nutritive energies. The latter represents the utmost reach of organic synthesis, and the former the ultimate of analysis. Nutrition, with its various results, is the agency employed in the one; oxidation, the agency employed in the other. Thus the two opposite processes to which life is due, nutrition and oxidation, has each its polar center, these poles being seated, at least in all the higher animals, at the opposite extremities of the body. We might, with some reason, proceed to consider the final result of the action of these organic poles. The nutritive germ ceases to be a part of the body which produces it, and is only temporarily connected with it for further nutrition and primary development. We may say the same thing of the mental germ, if we accept the belief entertained by the great mass of

mankind, and certainly not as yet disproved by the advocates of the opposite opinion.

We may further consider the relations of these two organic poles. The energies and substances organized in the body are not those which originally existed there. They are derived from the exterior world, and the body acts as a machine for their absorption and utilization. Food comes continually into the body, to be used primarily for nutrition, and ultimately for reproduction. Motor energy comes continually into the body, to be used primarily for animal activity, and ultimately for mental development. Thus from the outer world food and force, matter and motion, pour constantly into the body, where they are separately employed, and their excess directed to the two poles, food to the reproductive, force to the mental pole. At these two poles they are organized and exist as separate organisms, nourished by the body but not forming integral parts of it, the one fed with matter, the other with motion, and the body acting as an intermedium to absorb matter and force from outer nature, and apply them to the uses of its two diverse offspring.

The above consideration leads to still another. It has been frequently assumed that the animal body is organized solely under the influence of its external surroundings, and that its form is a result of a varied series of adaptations to outer conditions. But if our premises are correct there must be an inner force at work also, vigorously molding the body, and growing more declared and energetic as the animal reaches a higher stage of development. The rhizopod is not a mere creature of outer influences. It has, in virtue of the conditions of existence of protoplasm, the two polarities mentioned. Though acted upon by outer force, it reacts upon this force. Its lateral or sexual polarity controls the conditions and method of reproduction. Its motor-nutritive polarity controls the conditions of development. These influences act vigorously throughout the whole range of animal evolution as internal molding forces, resisting or directing the influences of the external molding forces. In the body of man, the highest animal, they have produced a remarkable double symmetry, which is strikingly indicative of its double polarity There is a lateral and a longitudinal polarity. The duplex paternal influence in the germ manifests itself in the mature body in a double organism, composed of two similar

halves connected in the median line. The longitudinal polarity is little less evident. The human body is an elongated, irregularly oval mass, branching at each extremity into limbs which are fundamentally similar. The body forms a hollow cylinder, being penetrated by a cavity which is devoted to digestion. Typically it is a symmetrical cylinder, but its internal symmetry has been broken by the requirements of the digestive function. The mesodermal arrangements do not detract from its symmetry. The bones and muscles answer to each other longitudinally. The excretory organs display a certain symmetry of arrangement, the kidneys for the excretion of liquid waste posteriorly, and the lungs for the excretion of gaseous waste anteriorly. Of the two remaining sets of organs, the vascular and the nervous, they seem, while generally related to the body as a whole, specially related to its polar regions. The vascular system, while engaged in the general duty of conveying nutriment and removing waste, has the special duty of elaborating germinal products and depositing them at the posterior, reproductive pole. The nervous system, while conveying motor influences to and from the tissues generally, is specially engaged in conveying motor impressions to the brain, the seat of the anterior or mental pole.

These poles answer to each other. They differ in organization from their great difference in use, but they are seated in the opposite extremities of the body, while the special sense organs are closely contiguous to the nervous pole, and the organs of food absorption lie in the vicinity of the reproductive pole. And as evidence that these poles are not directly but only secondarily concerned in the operations of the body, we have the fact that the cerebral and the reproductive organs may be both removed from the body, and its vital functions continue. In such a case there can be no reproduction, either mental or physical, no offspring, either spiritual or animal, yet the life of the animal as an individual is not necessarily affected, and may be long continued.

These parallels are, to say the least, curious, and they extend, though more or less masked, through the whole animal kingdom. But in the lower tribes the polarities have not yet become declared and localized. They are still vague and general, and have but a slight influence over the form of the body. Hence the forms of these lower animals are very largely molded by exterior influences. Their bilateral and their longitudinal symmetries are

but slightly or not at all displayed. In animals of somewhat higher organization, in which the polarities have become more localized, their effect upon the form is still largely masked by the influence of environing relations. Yet, though the poles assume unsymmetrical positions, the growing influence of the polar principle of organization is usually manifest. In the higher animal tribes the polar force asserts itself positively, and the result is a harmonious combination of functions arising from two sets of influences, those of external nature and those of the internal organic conditions. The formative energies inherent in protoplasm assert themselves against the irregular influences of the outer world, and produce in the highest animal a form of marked symmetry.

The polarity of the animal body is, in fact, fourfold in a somewhat fuller sense than here indicated. Each of the longitudinal poles is a double organ, so that each lateral half of the body possesses its longitudinal poles. And the brain of each half is directly connected with and controls the organic functions of the other half. There is thus a cross relation between the anterior and posterior poles. Each lateral half is, in a double sense, polar to the other half, and each may be looked upon as the representative of one of the parental organisms.

In the highest animals the action of the external forces must harmonize with, not oppose these internal energies. The polarities are not distinctly localized in the lowest animals, and there is little resistance to the action of external influences. The body is molded from without. But significantly, of the several lines of animal development, the vertebrate, that in which lateral and longitudinal polarity is most declared, has progressed far beyond the less symmetrical lines. With every step of development the influence of the polar tendencies grows more declared, while the molding agency of external force is more and more confined to superficial variations. In man the organization is markedly polar, and the molding influences of external nature are subordinate to the influence of the internal tendencies.

There is a minor phase of this organic polarity to which a brief allusion is desirable. In a former paper the influence of oxygen on the body was considered, and the relations of oxygenation and nutrition shown. Oxygen, in fact, is the servant of the motor function, and the constant foe of nutrition. From this

point of view it becomes interesting to find that the outer layer, the sensory region of the body, is the normal seat of ingestion of oxygen. This is particularly the case in the lowest animals. Food is ingested and dealt with by the interior substance of the body. Energy and oxygen, the agent of energy, are absorbed by the outer layer. This polarity of the function of oxidation is masked as that of energy grows strongly declared. The necessity of protection of the oxygen-absorbing tissue causes its inclusion within the body, though in the highest forms it retains indications of an invagination of the ectodermal tissue, as in the gills of fishes, and the lungs of land animals with their special nasal channel of external communication.

In one kingdom of the organic world, the vegetable kingdom, in which the sensory function fails to develop itself, the oxygenating function takes its place and becomes the anterior pole in a longitudinally polar organism. The symmetry of plants is, in this sense, closely analogous to that of animals. In all the higher forms of the plant world we find a cylindrical, elongated trunk with branching extremities. The two sets of branches are fundamentally identical, though they differ through the influence of functional differences. A tree, however, is a colony, and we must look upon the product of a single bud, with its cylindrical stem, its leaves and rootlets, as the individual vegetable organism. There is here no sensory pole, but there are analytic and synthetic poles. The leaves absorb oxygen, the rootlets absorb food. The former answer to the lungs, the latter to the intestines of animals. But as these functions are here complicated with, and subordinated to, no higher ones, they become the principal molding agencies, and the plant becomes a symmetrically polar oxynutritive organism. It probably possesses the double polarity which clearly exists in animals. The lateral, sexual polarity of animals seems to be replaced by a cylindrical polarity in plants, the inner and outer layers of active tissues which bound the sap channel perhaps possessing these opposite polarities. The other polarity, that of oxygenation and nutrition, is a longitudinal one; and thus the higher plant, as distinctly as the higher animal, is deeply molded by its internal constitution, and owes only its less fundamental, specific differences to the influence of external circumstances.

We need not carry this consideration further. It certainly

seems evident that the animal body is fundamentally molded by the energies of a double polarity, the one arising from the chemical character, and the other from the physical relations of protoplasm. The influence of external energies, strongly declared in the early phases of animal evolution, becomes less and less declared as the polar energies assert themselves, so that eventually the action of external force is confined to producing the minor, specific differences of organization; while the deep-lying, typical characteristics of organic form are due to the action of the polar energies.

And the character of the polarity specially referred to in this paper may be thus epitomized. Nutrition is primarily devoted to the growth and preservation of the individual animal, while its excess or overflow is directed to the reproductive pole, where it yields the germ of a new animal. Motor influence is primarily devoted to the vitality and activity of the individual animal, while its excess is directed to and retained in the sensory pole, where it forms the germ of a mental organism. The one flows posteriorly, the other anteriorly to their respective poles. The material germ is more matter than energy, the mental germ more energy than matter. The one is the ultimate of material or chemical complexity, the other of motor complexity. As compared with each other we may look upon the material germ as possessed of maximum matter with minimum motion; and the mental germ of minimum matter with maximum motion; their essential difference consisting in the complexity of material aggregation in the one, and of motor aggregation in the other.

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NOTE ON THE CLASSIFICATION OF MOTHS.

BY A. R. GROTE.

WHEN we take a general survey of the different classifications proposed by authors, we must be struck with the different ideas expressed with regard to the composition of families and sub-families. At a glance we see that the sub-families of the Bombycidæ and those of the Pyralidæ (as the last are arranged in the "New Check List") have a higher value than the divisions of the Noctuidæ and Geometridæ, as adopted by Guenée and Packard. They rest on peculiarly strong structural grounds,